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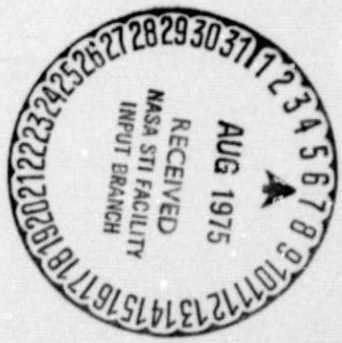
PRELIMINARY VIBRATION, ACOUSTIC, AND SHOCK DESIGN AND TEST CRITERIA FOR COMPONENTS ON THE HEAO-C SPACECRAFT

Systems Dynamics Laboratory

July 1975



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16. ABSTRACT

These vibration, acoustic, and shock specifications provide the qualification test criteria for spacecraft components and subassemblies and for the High Energy Astronomy Observatory (HEAO-C) experiments. The HEAO-C has been divided into zones and subzones to obtain simple component groupings. Zones are designated primarily to assist in determining the applicable specification. A Subzone (General Specification) is available for use when the location of the component is known but component design and weight are not well defined. When the location, weight, and mounting configuration of the component are known, the appropriate Subzone weight ranges (-A, -B, etc.) are available. Experiment and specific component specifications are available.

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DEFINITION OF SYMBOLS

CEI	Configuration End Item
D. A. Disp.	Double Amplitude Displacement
dB/oct.	decibels per octave
G's peak	peak acceleration
g^2/Hz	acceleration spectral density
g_{rms}	root mean square acceleration
HEAO	High Energy Astronomy Observatory
ICD	Interface Control Document
MSFC	Marshall Space Flight Center
SPL	Sound Pressure Level

SUMMARY

The vibration, acoustic, and shock specifications provide the qualification test criteria for spacecraft components and subassemblies and for the High Energy Astronomy Observatory (HEAO-C) experiments. The HEAO-C has been divided into zones and subzones to obtain simple component groupings. Zones are designated primarily to assist in determining the applicable specification. A Subzone (General Specification) is available for use when the location of the component is known but component design and weight are not well defined. When the location, weight, and mounting configuration of the component are known, the appropriate subzone weight ranges (-A, -B, etc.) are available. Experiment and specific component specifications are available.

Included with the specifications are vibration, acoustic, shock, transportation, handling, and acceptance test requirements and procedures. Selection of applicable vibration, acoustic, and shock specifications are also included.

SECTION I. INTRODUCTION

This document presents the specifications for vibration, acoustic, and shock qualification testing of components and subassemblies on the High Energy Astronomy Observatory (HEAO-C). Also presented are specifications for transportation, handling, and acceptance testing. The HEAO-C specifications are for the Experiment Modules, which consist of three experiment bays, and the Equipment Module. Subzones (General Specifications) are presented for all locations. Specific component specifications are presented for some components and subassemblies. Specifications for experiment modules and support equipment are also provided.

The specifications cannot provide all the information necessary for qualification testing of each individual component and subassembly. Consequently, the use of this document must be under the cognizance of qualified dynamics and test engineers. The originating agency [Marshall Space Flight Center (MSFC), ED23] will assist in the proper use of these specifications.

SECTION II. VIBRATION AND SHOCK QUALIFICATION TEST REQUIREMENTS AND PROCEDURES

The following requirements and procedures apply only to qualification testing:

A. Specimen

Test specimens will be production components or experiments in accordance with current manufacturing drawings. Supporting brackets and attachment hardware (lines, valves, etc.) will be included in all tests to achieve dynamic similarity to actual installation. Hardware included in the test setup is part of the test specimen.

B. Fixture

The fixture will support the specimen in the manner simulating actual installation. The fixture will be designed to minimize fixture response at resonances within the test frequency range. A sinusoidal resonant survey will be performed on all fixtures prior to initiation of testing.

The fixture design and specimen installation should be approved by responsible dynamics and test engineers prior to testing.

C. Test Specimen and Fixture Resonance Survey

A sinusoidal resonance survey test is recommended in the fixture and instrumentation diagnostic process and in developmental testing. The recommended sweep rate is 1 oct./min from 5 to 2000 to 5 Hz at the following amplitudes:

5- 62 Hz @ 0.0050 in. (0.013 cm) D. A. Disp.
62-2000 Hz @ 1.0 G's peak

D. Test Amplitudes

All component test amplitudes will be applied as inputs to the component bracketry at the interface of the bracketry and the test fixture. The inputs will be applied along each of three mutually perpendicular axes as referenced to the interface of the component and the payload primary structure. These axes are determined by the vehicle primary structure and are defined as Radial, Longitudinal (Long.), and Tangential (Tang.).

The control accelerometer will be mounted on the test fixture at the point where the test specimen or specimen supporting bracketry attaches to the test fixture, or as determined by the fixture survey.

E. Test Sequence

The qualification testing order will be:

- Acceptance Vibration Test (as required, Section VI)
- Flight Random Vibration Test
- Vehicle Dynamics Test
- Shock Spectrum Test
- Acoustic Test (as required, section IV)

Acceptance testing should be completed in all axes prior to any other qualification testing. The flight random vibration, vehicle dynamics, and shock testing should be completed in one axis before proceeding to the next. When shock testing is performed on separate test equipment, all vibration testing will be completed prior to shock testing.

F. Functional Performance

Specimens that function in the dynamic environment will perform to their functional specifications prior to, during, and after each qualification test.

G. Random Vibration Tests

Test equipment equalization will be accomplished by either of the following methods:

- Initial equalization is obtained by using actual test specimens and reduced vibration inputs. Final equalization is then obtained by applying short duration excitation at the specified test amplitudes.

- A mass simulated dummy component is subjected to the specified test inputs as in the above method. After equalization, the dummy component is replaced by the actual component, and equalization is verified by applying short duration excitation at the specified test amplitudes. Test amplitudes and durations are provided in the applicable specifications. Test setup and equalization time should be minimized. Neither of these time durations will be included in the specified test duration.

H. Vehicle Dynamics Test

Test amplitudes are provided in the applicable specification. The specified frequency spectrum will be swept logarithmically at the rate of 3 oct./min.

I. Shock Spectrum Test

Shock spectra are stated for each specification. Any pulse that results in a spectrum within the test tolerances at every frequency of the specified shock spectrum is acceptable. Either mechanical or ordnance shock testing is acceptable. During mechanical shock testing, the test specimen will be subjected to two shocks in each axis (one in each direction) for a total of six shocks. During ordnance shock testing, the specimen will be subjected to one shock that satisfies the applicable specifications in one of the three axes.

J. Combined Environments

Vibration, shock, and acoustic testing under various combined environments will be specified, when required, by the responsible MSFC organization.

K. Test Tolerances

The following test tolerances are considered acceptable:

• Random Vibration	
--Overall Root Mean Square Acceleration	±10%
--Acceleration Spectral Density (referenced to an analysis bandwidth of 25 Hz or less)	+100% -30%
--Test Duration	+10% -0%
• Vehicle Dynamics	
--Sinusoidal Acceleration	+20% -10%
--Sinusoidal Control Signal Maximum Harmonic Distortion	±10%
--Frequency	±5%
• Shock Spectrum	
--Spectrum Acceleration (When analyzed with a 1/3 oct. shock spectrum analyzer and 5 percent damping)	+40% -20%

L. Failure Determination

A specimen will be considered as having failed a particular test if the specimen malfunctions during or after the test or if post-test prescribed inspection reveals structural damage. All test failures will be immediately reported to MSFC, ED23, in accordance with the requirements of DR's RA-08 or RA-11, as applicable.

M. Deviation From Specification

Deviation from these specifications may be obtained only from the originating agency (MSFC, ED23). All deviations will be stated in the test report.

N. Test Reports

Reports will be in accordance with DR's, TM-03, or TM-06, as applicable. The report submitted will describe in detail the tests performed and the results of the tests. The report will include drawings, sketches, and photographs showing in detail all measurement locations. The report will include all calibration and measured test levels and any other information pertinent to the acquisition, reduction, analysis, and interpretation of the test data. Equalization levels and durations will be included.

Progress reports will be provided to the originating agency, as requested.

SECTION III. SELECTION OF APPLICABLE VIBRATION AND SHOCK SPECIFICATIONS FOR STRUCTURALLY MOUNTED COMPONENTS AND EXPERIMENTS

The selection of the correct qualification specification is essential in developing component confidence and reliability. The following general discussion should be considered before making such a selection.

A zonal technique has been used in generating and presenting the qualification specifications. Using this technique, the HEAO-C has been divided into zones (Figures 1 and 2). Each zone is then further divided into subzones. Each subzone is composed of various weight ranges. The zonal technique has been used because it provides a direct approach to correctly determine the applicable specification for any component or subassembly.

Three distinct types of component and subassembly qualification specifications are presented.

1. Subzone (General Specification)
2. Subzone weight ranges (-A, -B, etc.)
3. Specific Component Specification

A Subzone (General Specification) pertains to all components and subassemblies located within a particular subzone or zone. These specifications are labeled "General" because the stated specifications are sufficient to qualify all components and subassemblies in that subzone. General Specifications are the maximum vibration environment for all of the structures within a subzone. Consequently, General Specifications usually result in more severe qualification specifications than weighted specifications. General Specifications should be used only when components cannot be located in the next two categories.

Subzone weight ranges have been determined for all practical locations. These specifications pertain to certain items (components, subassemblies, panels, etc.) located within a specific subzone. These subzones may be distinguished by the absence of the notation "General Specification" and the inclusion of a letter suffix (-A, -B, etc.) in the specification number. These weighted specifications are based on vibration environments for various types of local structures (skin, stringer, ring-frame, etc.).

Specific Spacecraft Component Specifications have been determined for certain components and subassemblies. The qualification specifications pertain to individual components and are based on the component's weight, location, and mounting configuration.

The appropriate qualification specification can be determined for a particular component or subassembly by the following procedure:

- Determine if a specific component specification exists, if not;
- Identify the zone in which the component or subassembly is located;
- Within this zone, determine the subzone in which the particular component or subassembly is located;
- Identify the subzone weight range (-A, -B, etc.) within this subzone that pertains to the component or subassembly of interest.
- The spacecraft/experiment interface vibration and shock test specifications are given in Section VII. Specifications for components and subsystems located on the experiments are not included. Therefore, the experimenters must derive and publish in a single contractor document the test specifications for the experiment components and subsystems on their respective experiments. These specifications must then be approved by MSFC, ED23. The Interface Control Document (ICD) and/or Configuration End Item (CEI) vibration, acoustic, and shock criteria along with experiment structural parameters will be used to derive these specifications.

SECTION IV. ACOUSTIC TEST REQUIREMENTS AND PROCEDURES

A. General Requirements

All structures and components requiring acoustic testing will be subjected to either broadband reverberant field or progressive wave testing. The acoustical random noise source for either type test will have an approximate normal amplitude distribution. Reverberant field testing is preferred for both structures and components. However, structural panels as well as components may be tested using progessive wave facilities where this type of test is justified.

B. Specification Selection

A zonal technique has been used in generating and presenting the qualification specifications. Using this technique, the HEAO spacecraft has been divided into zones as shown in Figure 1. Acoustic test specifications for each of these general zones are provided in Section VIII.

The appropriate qualification specification can be determined by identifying the zone where the component is located.

C. Reverberation Chamber Facilities

The test chamber will be of sufficient volume and dimensions to ensure that the insertion of the test specimen will not affect the generation and maintenance of a broadband diffuse sound field above 50 Hz. Normally, the test specimen will be suspended in the center of the test chamber with soft suspension cords. The suspension system will have a fundamental frequency of less than 25 Hz.

The sound field in the proximity of each major surface of any test specimen that will be subjected to external acoustic environments will be determined by either flush mounted microphones or microphones mounted approximately 0.25 in. (0.64 cm) from the specimen surface. The microphones may serve as the control measurements. When the placement of these microphones is not feasible or will compromise the test results, these measurements are not required. All other microphones, including at least three microphones that will serve as control measurements, will not be located in close proximity to any surface within the test chamber. The control measurements, whether flush mounted or field located, will be averaged to determine the sound field.

With the specimen in the test chamber, the sound pressure level spectrum will be shaped at a level approximately 6 dB less than the specification. The time required to shape the spectrum will be minimized to avoid possible premature damage to the test specimen. After completion of the spectrum shaping, the sound pressure level will be increased to the specified value, and the test will commence. As an alternative to reducing the sound pressure level while shaping the spectrum, a dummy specimen may be positioned in the test chamber, and the spectrum shaped at the test level. When the spectrum shaping has been completed, the dummy specimen will be replaced by the test specimen, and the test will commence.

D. Progressive Wave Facilities

The structural panel specimens may be tested in progressive wave facilities. The test specimen will be centrally mounted in the wall of the progressive wave duct. The width of the wave duct will be of sufficient distance to ensure minimum affects on the panel response characteristics.

Components may be tested in progressive wave facilities. The specimen will be centrally located in the progressive wave duct and suspended by a system having a fundamental frequency of less than 25 Hz. The cross section of the progressive wave duct will be of sufficient area relative to the frontal area of the test specimen, to ensure that the insertion of the test specimen will not affect the generation and maintenance of the progressive wave. The test specimen will have each major surface exposed to the sound field by orienting each major surface parallel to the progressive wave front. Each major surface will be exposed to the sound field for the full test duration.

For both types of progressive wave testing, the sound pressure level spectrum will be shaped without the test specimen in place. The uniformity of the sound field will be determined by locating at least three microphones in the proximity of the duct cross sectional plane where the test specimen will be mounted. After mounting the test specimen, the sound pressure level will be reestablished, and the test will commence. Alternatively, for structural panel specimen sound pressure level may be shaped at a level 6 dB less than the specification. The time required to shape the spectrum will be minimized to avoid premature damage.

E. Tolerances

The test time will be within 10 to-0 percent of the time stated in the specification. The overall sound pressure level and the individual one-third octave band sound pressure levels will be within 2 to-2 dB of the specification. The sound pressure level tolerance applies to the frequency range of 50 through 10,000 Hz. Below this frequency range, the capability of the testing facility will be the governing factor.

SECTION V. TRANSPORTATION AND HANDLING TEST REQUIREMENTS AND PROCEDURES

Transportation and handling specifications should be used for designing and testing component shipping containers. These specifications should not influence component design, but should provide information for shipping container design to ensure that the vibration amplitudes transmitted to the component do not exceed the design amplitudes.

A. Transportation

Transportation specifications are generally persented as G's peak sinusoidal sweep tests. Components should be monitored for resonances; dwell tests of 15 min each are required at each major resonance as noted during the sweep. If a component is shipped by rail, a shock test will be required to represent the train humping conditions. Any shock pulse may be used that results in a spectrum as severe as that specified.

Transportation tests may be eliminated if proof of adequate component protection can be provided.

B. Handling

Handling specifications are required to account for typical conditions that occur during loading or unloading operations. Tests for these conditions consist of numerous container drops from various orientations of the container.

Handling tests may be eliminated if proof of adequate component protection can be provided.

SECTION VI. ACCEPTANCE TEST REQUIREMENTS AND PROCEDURES

The requirement to do acceptance testing will be established for each program by the project manager. This document does not establish the requirement to do acceptance testing; however, it does give the acceptance test levels to be used if acceptance testing is required. If acceptance testing is required on the flight hardware, it will also be required on the qualification hardware. Acceptance test levels will, in general, be 6 dB below the vibration qualification composite level.

Test procedures and tolerances will be the same as specified in the appropriate sections of this document.

SECTION VII. VIBRATION AND SHOCK SPECIFICATIONS

A. Spacecraft Equipment

Zone 1-Spacecraft Equipment Module, Sta. -4 in. (-10 cm) to 33 in. (84 cm)

Subzone 1-1-Skin (Shear Web) Panels (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

	20 Hz @ 0.0050 g^2/Hz
20-	110 Hz @ +6 dB/oct.
110-	500 Hz @ 0.15 g^2/Hz
500-	2000 Hz @ -9 dB/oct.
	2000 Hz @ 0.0024 g^2/Hz

Composite = 9.9 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

	20 Hz @ 0.020 g^2/Hz
20-	110 Hz @ +6 dB/oct.
110-	500 Hz @ 0.60 g^2/Hz
500-	2000 Hz @ -9 dB/oct.
	2000 Hz @ 0.0095 g^2/Hz

Composite = 19.9 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

5-	15 Hz @ 0.5 G's peak
15-	25 Hz @ 1.4 G's peak
25-	40 Hz @ 2.0 G's peak
40-	50 Hz @ 0.5 G's peak

4. Shock Spectrum Criteria (2 shocks/axis)

Sta. -4 in. (-10 cm) to 10 in. (25 cm)	Sta. 11 in. (28 cm) to 33 in. (84 cm)
100 - 320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 - 10,000 Hz @ 1600 G's Peak	@ 800 G's Peak
	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-2. Skin Stiffeners and Longerons (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0022 g^2/Hz
20- 200 Hz @ +6 dB/oct.
200- 800 Hz @ 0.022 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0016 g^2/Hz

Composite = 5.0 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.0052 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.052 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0034 g^2/Hz

Composite = 7.7 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

5-15 Hz @ 0.5 G's peak
15-25 Hz @ 1.4 G's peak
25-40 Hz @ 2.0 G's peak
40-50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

Sta. -4 in. (-10 cm) to 10 in. (25 cm)
100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 1600 G's Peak

Sta. 11 in. (28 cm) to 33 in. (84 cm)
@ +12 dB/oct.
@ +4.5 dB/oct.
@ 800 G's Peak
(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3. Honeycomb Panel Structure (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0085 g^2/Hz
20- 120 Hz @ +6 dB/oct.
120- 520 Hz @ 0.32 g^2/Hz
520-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0051 g^2/Hz

Composite = 14.9 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.034 g^2/Hz
20- 120 Hz @ +6 dB/oct.
120- 520 Hz @ 1.30 g^2/Hz
520-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.023 g^2/Hz

Composite = 29.8 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

5-15 Hz @ 0.5 G's peak
15-25 Hz @ 1.4 G's peak
25-40 Hz @ 2.0 G's peak
40-50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

Honeycomb Floor	Honeycomb Walls
100 - 320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 - 10,000 Hz @ 800 G's Peak	@ 480 G's Peak
(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-A-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor < 5 lb (2.3 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis	Long. and Tang. Axes
20 Hz @ 0.0085 g^2/Hz	20 Hz @ 0.0040 g^2/Hz
20- 120 Hz @ +6 dB/oct.	20- 120 Hz @ +6 dB/oct.
120- 520 Hz @ 0.32 g^2/Hz	120-1000 Hz @ 0.14 g^2/Hz
520-2000 Hz @ -9 dB/oct.	1000-2000 Hz @ -6 dB/oct.
2000 Hz @ 0.0051 g^2/Hz	2000 Hz @ 0.035 g^2/Hz
Composite = 14.9 g_{rms}	Composite = 14.[illegible] g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

Radial Axis	Long. and Tang. Axes
20 Hz @ 0.034 g^2/Hz	20 Hz @ 0.016 g^2/Hz
20- 120 Hz @ +6 dB/oct.	20- 120 Hz @ +6 dB/oct.
120- 520 Hz @ 1.30 g^2/Hz	120-1000 Hz @ 0.58 g^2/Hz
520-2000 Hz @ -9 dB/oct.	1000-2000 Hz @ -6 dB/oct.
2000 Hz @ 0.023 g^2/Hz	2000 Hz @ 0.14 g^2/Hz
Composite = 29.8 g_{rms}	Composite = 28.9 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

5-15 Hz @ 0.5 G's peak
15-25 Hz @ 1.4 G's peak
25-40 Hz @ 2.0 G's peak
40-50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

Honeycomb Floor	Honeycomb Walls
100 - 320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 - 10,000 Hz @ 800 G's Peak	@ 480 G's Peak
(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-B-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor > 5 (2.3) but < 15 lb (6.8 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis		Long. and Tang. Axes	
	20 Hz @ 0.0085 g^2/Hz		20 Hz @ 0.0040 g^2/Hz
20 -	105 Hz @ + 6 dB/oct.	20 -	105 Hz @ + 6 dB/oct.
105 -	580 Hz @ 0.23 g^2/Hz	105 -	1000 Hz @ 0.10 g^2/Hz
580 -	2000 Hz @ -9 dB/oct.	1000 -	2000 Hz @ -6 dB/oct.
	2000 Hz @ 0.0051 g^2/Hz		2000 Hz @ 0.025 g^2/Hz
	Composite = 13.6 g_{rms}		Composite = 12.4 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

Radial Axis		Long. and Tang. Axes	
	20 Hz @ 0.034 g^2/Hz		20 Hz @ 0.016 g^2/Hz
20 -	105 Hz @ + 6 dB/oct.	20 -	105 Hz @ + 6 dB/oct.
105 -	580 Hz @ 0.95 g^2/Hz	105 -	1000 Hz @ 0.42 g^2/Hz
580 -	2000 Hz @ -9 dB/oct.	1000 -	2000 Hz @ -6 dB/oct.
	2000 Hz @ 0.023 g^2/Hz		2000 Hz @ 0.10 g^2/Hz
	Composite = 27.2 g_{rms}		Composite = 24.8 g_{rms}

3. Vehicle Dynamics Criteria (5 - 50 Hz @ 3 oct./min)

5 -	15 Hz @ 0.5 G's peak
15 -	25 Hz @ 1.4 G's peak
25 -	40 Hz @ 2.0 G's peak
40 -	50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

	Honeycomb Floor	Honeycomb Walls
100 -	320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 -	800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 -	10,000 Hz @ 800 G's Peak.	@ 480 G's Peak
	(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-C-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor > 15 (6.8) but < 25 lb (11.4 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.0085 g^2/Hz			20 Hz @ 0.0040 g^2/Hz
20	-	85 Hz @ +6 dB/oct.	20	-	85 Hz @ +6 dB/oct.
85	-	680 Hz @ 0.15 g^2/Hz	85	-	1000 Hz @ 0.067 g^2/Hz
680	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.0051 g^2/Hz			2000 Hz @ 0.017 g^2/Hz
		Composite = 11.8 g_{rms}			Composite - 9.9 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.034 g^2/Hz			20 Hz @ 0.016 g^2/Hz
20	-	85 Hz @ +6 dB/oct.	20	-	85 Hz @ +6 dB/oct.
85	-	680 Hz @ 0.60 g^2/Hz	85	-	1000 Hz @ 0.27 g^2/Hz
680	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.023 g^2/Hz			2000 Hz @ 0.067 g^2/Hz
		Composite = 23.6 g_{rms}			Composite = 19.8 g_{rms}

3. Vehicle Dynamics Criteria (5 - 50 Hz @ 3 oct./min)

5	-	15 Hz @ 0.5 G's peak
15	-	25 Hz @ 1.4 G's peak
25	-	40 Hz @ 2.0 G's peak
40	-	50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

Honeycomb Floor			Honeycomb Walls
100	-	320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320	-	800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800	-	10,000 Hz @ 800 G's Peak	@ 480 G's Peak
		(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-D-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor > 25 (11.4) but < 40 lb (18.2 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.0085 g^2/Hz			20 Hz @ 0.0040 g^2/Hz
20	-	72 Hz @ +6 dB/oct.	20	-	72 Hz @ +6 dB/oct.
72	-	750 Hz @ 0.11 g^2/Hz	72	-	1000 Hz @ 0.050 g^2/Hz
750	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.051 g^2/Hz			2000 Hz @ 0.012 g^2/Hz
		Composite = 10.6 g_{rms}			Composite = 8.5 g_{rms}

2. Flight Random Vibration Criteria (1 min/axis)*

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.034 g^2/Hz			20 Hz @ 0.016 g^2/Hz
20	-	72 Hz @ +6 dB/oct.	20	-	72 Hz @ +6 dB/oct.
72	-	750 Hz @ 0.44 g^2/Hz	72	-	1000 Hz @ 0.20 g^2/Hz
750	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.023 g^2/Hz			2000 Hz @ 0.050 g^2/Hz
		Composite = 21.2 g_{rms}			Composite = 17.1 g_{rms}

3. Vehicle Dynamics Criteria (5 - 50 Hz @ 3 oct./min)

5	-	15 Hz @ 0.5 G's peak
15	-	25 Hz @ 1.4 G's peak
25	-	40 Hz @ 2.0 G's peak
40	-	50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

	Honeycomb Floor	Honeycomb Walls
100 -	320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 -	800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 -	10,000 Hz @ 800 G's Peak	@ 480 G's Peak
	(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-E-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor > 40 (18.2) but < 70 lb (31.8 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.0085 g^2/Hz			20 Hz @ 0.0040 g^2/Hz
20	-	60 Hz @ + 6 dB/oct.	20	-	72 Hz @ + 6 dB/oct.
60	-	750 Hz @ 0.075 g^2/Hz	72	-	1000 Hz @ 0.050 g^2/Hz
750	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.0040 g^2/Hz			2000 Hz @ 0.012 g^2/Hz
		Composite = 8.8 g_{rms}			Composite = 8.5 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

Radial Axis			Long. and Tang. Axes		
		20 Hz @ 0.034 g^2/Hz			20 Hz @ 0.016 g^2/Hz
20	-	60 Hz @ + 6 dB/oct.	20	-	72 Hz @ + 6 dB/oct.
60	-	750 Hz @ 0.30 g^2/Hz	72	-	1000 Hz @ 0.20 g^2/Hz
750	-	2000 Hz @ -9 dB/oct.	1000	-	2000 Hz @ -6 dB/oct.
		2000 Hz @ 0.016 g^2/Hz			2000 Hz @ 0.050 g^2/Hz
		Composite = 17.6 g_{rms}			Composite = 17.1 g_{rms}

3. Vehicle Dynamics Criteria (5 - 50 Hz @ 3 oct./min)

5	-	15 Hz @ 0.5 G's peak
15	-	25 Hz @ 1.4 G's peak
25	-	40 Hz @ 2.0 G's peak
40	-	50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

	Honeycomb Floor	Honeycomb Walls
100 -	320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 -	800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 -	10,000 Hz @ 800 G's Peak	@ 480 G's Peak
	(No test required.)	(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-3-F-Input to Components on Equipment Compartment Honeycomb Wall or Floor. Total Weight of Components on the Wall or Floor > 70 lb (31.8 kg)

1. Acceptance Test Criteria (1 min/axis)

Radial Axis	Long. and Tang. Axes
20 Hz @ 0.0085 g^2/Hz	20 Hz @ 0.0040 g^2/Hz
20- 50 Hz @ +6 dB/oct.	20- 72 Hz @ +6 dB/oct.
50- 750 Hz @ 0.050 g^2/Hz	72-1000 Hz @ 0.050 g^2/Hz
750-2000 Hz @ -9 dB/oct.	1000-2000 Hz @ -6 dB/oct.
2000 Hz @ 0.0027 g^2/Hz	2000 Hz @ 0.012 g^2/Hz
Composite = 7.2 g_{rms}	Composite = 8.5 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

Radial Axis	Long. and Tang. Axes
20 Hz @ 0.034 g^2/Hz	20 Hz @ 0.016 g^2/Hz
20- 50 Hz @ +6 dB/oct.	20- 72 Hz @ +6 dB/oct.
50- 750 Hz @ 0.20 g^2/Hz	72-1000 Hz @ 0.20 g^2/Hz
750-2000 Hz @ -9 dB/oct.	1000-2000 Hz @ -6 dB/oct.
2000 Hz @ 0.011 g^2/Hz	2000 Hz @ 0.050 g^2/Hz
Composite = 14.4 g_{rms}	Composite = 17.1 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

5-15 Hz @ 0.5 G's peak
15-25 Hz @ 1.4 G's peak
25-40 Hz @ 2.0 G's peak
40-50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

Honeycomb Floor	Honeycomb Walls
100 - 320 Hz @ +12 dB/oct.	@ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.	@ +4.5 dB/oct.
800 - 10,000 Hz @ 800 G's Peak	@ 480 G's Peak
(No test required.)	No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Subzone 1-4-Input to Components Mounted on the Propellant Tank Frame

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0020 g^2/Hz
20- 45 Hz @ +6 dB/oct.
45- 150 Hz @ 0.0090 g^2/Hz
150-2000 Hz @ -3 dB/oct.
2000 Hz @ 0.00064 g^2/Hz

Composite = 2.2 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.0020 g^2/Hz
20- 45 Hz @ +6 dB/oct.
45- 150 Hz @ 0.0090 g^2/Hz
150-2000 Hz @ -3 dB/oct.
2000 Hz @ 0.00064 g^2/Hz

Composite = 2.2 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3oct./min)

5-15 Hz @ 0.5 G's peak
15-25 Hz @ 1.4 G's peak
25-40 Hz @ 2.0 G's peak
40-50 Hz @ 0.5 G's peak

4. Shock Spectrum Test Criteria (2 shocks/axis)

No Shock Test Required

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

Zone 2-Spacecraft Experiment Module, Sta. 33 in. (84 cm) to 80 in. (203 cm)

Subzone 2-1-Skin (Shear Web) Panels (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0050 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.15 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0024 g^2/Hz

Composite = 9.9 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.020 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.60 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0095 g^2/Hz

Composite = 19.9 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 1.6 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 400 G's Peak

(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

**No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Subzone 2-2-Skin Stiffeners and Longerons (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0050 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.050 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0037 g^2/Hz

Composite = 7.7 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.023 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.23 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.015 g^2/Hz

Composite = 15.4 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 1.6 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 400 G's Peak

(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

**No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Zone 3 - Spacecraft Experiment Module, Sta. 80 in. (203 cm) to 152 in. (386 cm).

Subzone 3-1-Skin (Shear Web) Panels (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0062 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.19 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0030 g^2/Hz

Composite = 11.1 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.025 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.75 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.012 g^2/Hz

Composite = 22.2 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 4.0 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 200 G's Peak

(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

**No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Subzone 3-2-Skin Stiffeners and Longerons (General Specifications)

1. **Acceptance Test Criteria (1 min/axis)**

20 Hz @ 0.0063 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.063 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0046 g^2/Hz

Composite = 8.6 g_{rms}

2. **Flight Random Vibration Criteria (3 min/axis)***

20 Hz @ 0.029 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.29 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.019 g^2/Hz

Composite = 17.2 g_{rms}

3. **Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)**

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 4.0 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. **Shock Spectrum Test Criteria (2 shocks/axis)**

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 200 G's Peak
(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.

**No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Zone 4-Spacecraft Experiment Module, Sta. 152 in. (386 cm) to 161 in. (409 cm)

Subzone 4-1-Skin (Shear Web) Panels (General Specifications)

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0050 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.15 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0024 g^2/Hz

Composite = 9.9 g_{rms}

2. Flight Random Vibration Criteria (3 min/axis)*

20 Hz @ 0.020 g^2/Hz
20- 110 Hz @ +6 dB/oct.
110- 500 Hz @ 0.60 g^2/Hz
500-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0095 g^2/Hz

Composite = 19.9 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 4.0 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 100 G's Peak
(No test required.)

***If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.**

****No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.**

Subzone 4-2-Skin Stiffeners and Longerons (General Specifications)

1. **Acceptance Test Criteria (1 min/axis)**

20 Hz @ 0.0050 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.050 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0037 g^2/Hz

Composite = 7.7 g_{rms}

2. **Flight Random Vibration Criteria (3 min/axis)***

20 Hz @ 0.023 g^2/Hz
20- 200 Hz @ +3 dB/oct.
200- 800 Hz @ 0.23 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.015 g^2/Hz

Composite = 15.4 g_{rms}

3. **Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)**

Long. Axis	Radial and Tang. Axes
5-10 Hz @ 1.2 G's peak**	5-10 Hz @ 4.0 G's peak**
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. **Shock Spectrum Test Criteria (2 shocks/axis)**

100 - 320 Hz @ +12 dB/oct.
320 - 800 Hz @ +4.5 dB/oct.
800 - 10,000 Hz @ 100 G's Peak
(No test required.)

*If the component is a protoflight item, then the test time shall be reduced to 1 min/axis.
**No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

B. Experiments and Experiment Equipment

Input to C-1 (Jacobson) High Spectral Resolution Gamma Ray Spectrometer Experiment.

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0033 g^2/Hz
20- 140 Hz @ +3 dB/oct.
140- 800 Hz @ 0.024 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.00016 g^2/Hz

Composite = 5.0 g_{rms}

2. Flight Random Vibration Criteria (1 min/axis)

20 Hz @ 0.0034 g^2/Hz
20- 140 Hz @ +3 dB/oct.
140- 800 Hz @ 0.025 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0017 g^2/Hz

Composite = 5.1 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis*	Radial and Tang. Axes*
5-10 Hz @ 1.2 G's peak▲	5-10 Hz @ 4.0 G's peak▲
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.5 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shock/axis)

100- 320 Hz @ +12 dB/oct.
320- 800 Hz @ +4.5 dB/oct.
800-10,000 Hz @ 100 G's peak
(No test required.)

*Response limits To Be Determined.
▲No test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Input to C-2 (Koch - Peters) Isotopic Composition of Primary Cosmic Ray Experiment.

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0014 g^2/Hz
20- 100 Hz @ +3 dB/oct.
100- 800 Hz @ 0.0070 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.00046 g^2/Hz

Composite = 2.8 g_{rms}

2. Flight Random Vibration Criteria (1 min/axis)

20 Hz @ 0.0014 g^2/Hz
20- 100 Hz @ +3 dB/oct.
100- 800 Hz @ 0.0070 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.00046 g^2/Hz

Composite = 2.8 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct/min)

Long. Axis*	Radial and Tang. Axes*
5-10 Hz @ 1.2 G's peak $^{\Delta}$	5-10 Hz @ 1.6 G's peak $^{\Delta}$
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.0 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100- 320 Hz @ +12 dB/oct.
320- 800 Hz @ +4.5 dB/oct.
800-10,000 Hz @ 400 G's peak
(No test required)

*Response limits To Be Determined.
ΔNo test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Input to C-3 (IWS) Heavy Nuclei Experiment

1. Acceptance Test Criteria (1 min/axis)

20 Hz @ 0.0031 g^2/Hz
20- 160 Hz @ +3 dB/oct.
160- 800 Hz @ 0.024 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0016 g /Hz

Composite = 5.0 g_{rms}

2. Flight Random Vibration Criteria (1 min/axis)

20 Hz @ 0.0036 g^2/Hz
20- 160 Hz @ +3 dB/oct.
160- 800 Hz @ 0.028 g^2/Hz
800-2000 Hz @ -9 dB/oct.
2000 Hz @ 0.0019 g^2/Hz

Composite = 5.4 g_{rms}

3. Vehicle Dynamics Criteria (5-50 Hz @ 3 oct./min)

Long. Axis*	Radial and Tang. Axes*
5-10 Hz @ 1.2 G's peak$^{\Delta}$	5-10 Hz @ 4.0 G's peak$^{\Delta}$
10-25 Hz @ 1.4 G's peak	10-50 Hz @ 1.0 G's peak
25-40 Hz @ 2.5 G's peak	
40-50 Hz @ 0.5 G's peak	

4. Shock Spectrum Test Criteria (2 shocks/axis)

100- 320 Hz @ +12 dB/oct.
320- 800 Hz @ +4.5 dB/oct.
800-10,000 Hz @ 200 G's peak
(No test required.)

*Response limits To Be Determined.
ΔNo test required if analysis shows no component resonant frequencies in the frequency range 5-10 Hz.

Zones 1 through 4. HEAO-C Equipment Module and Spacecraft Support Components (General Specification)

External

(1/3-oct. Band Acoustic Specification in dB re 20 $\mu N/m^2$)

Geometric Mean Frequency (Hz)	Lift-off And Boundary Layer
5.0	98.0
6.3	102.0
8.0	105.0
10.0	108.0
12.5	111.0
16.0	114.0
20.0	117.0
25.0	120.0
31.5	122.0
40.0	125.0
50.0	127.0
63.0	129.0
80.0	131.0
100.0	132.0
125.0	133.5
160.0	134.5
200.0	135.5
250.0	136.0
315.0	135.5
400.0	135.0
500.0	133.5
630.0	131.0
800.0	129.0
1,000.0	127.0
1,250.0	125.0
1,600.0	123.0
2,000.0	121.0
2,500.0	119.0
3,150.0	117.0
4,000.0	115.0
5,000.0	112.5
6,300.0	110.0
8,000.0	108.0
10,000.0	106.5
Overall SPL	146.0
Duration (sec)	180.0

Zones 2 through 4. HEAO-C Experiments and Experiment Support Components (General Specification)

External

(1/3-oct. Band Acoustic Specification in dB re 20 $\mu N/m^2$)

Geometric Mean Frequency (Hz)	Lift-off And Boundary Layer
5.0	98.0
6.3	102.0
8.0	105.0
10.0	108.0
12.5	111.0
16.0	114.0
20.0	117.0
25.0	120.0
31.5	122.0
40.0	125.0
50.0	127.0
63.0	129.0
80.0	131.0
100.0	132.0
125.0	133.5
160.0	134.5
200.0	135.5
250.0	136.0
315.0	135.5
400.0	135.0
500.0	133.5
630.0	131.0
800.0	129.0
1,000.0	127.0
1,250.0	125.0
1,600.0	123.0
2,000.0	121.0
2,500.0	119.0
3,150.0	117.0
4,000.0	115.0
5,000.0	112.5
6,300.0	110.0
8,000.0	108.0
10,000.0	106.5
Overall SPL	140.0
Duration (sec)	60.0

SECTION IX. TRANSPORTATION SPECIFICATIONS

A. Vibration

Vibration test frequencies should be swept logarithmically from 5 Hz to the maximum frequency and back to 5 Hz at 1 oct. /min in each of three mutually perpendicular axes. Criteria below 5 Hz are for design consideration only and no test is required. Dwell for 15 min at each major component resonance at the amplitude specified for the sweep test.

1. Aircraft

- Jet (5-2000-5 Hz @ 1 oct./min)

  5- 10 Hz @ 0.022 in. (0.056 cm) D. A. Disp.
  10- 35 Hz @ 0.11 G's peak
  35- 200 Hz @ 0.0017 in. (0.0043 cm) D. A. Disp.
  200-2000 Hz @ 3.5 G's peak

- Propeller (5-700-5 Hz @ 1 oct. /min)

  2- 4 Hz @ 0.42 in. (1.07 cm) D. A. Disp. *
  4- 5 Hz @ 0.35 G's peak*
  5- 12 Hz @ 0.35 G's peak
  12- 55 Hz @ 0.046 in. (0.127 cm) D. A. Disp.
  55-300 Hz @ 7.0 G's peak
  300-700 Hz @ 3.5 G's peak

- Helicopter (5-600-5 Hz @ 1 oct./min)

  5- 12 Hz @ 0.22 in. (0.56 cm) D. A. Disp.
  12- 40 Hz @ 1.6 G's peak
  40- 55 Hz @ 0.019 in. (0.048 cm) D. A. Disp.
  55-120 Hz @ 3.0 G's peak
  120-170 Hz @ 0.0040 in. (0.010 cm) D. A. Disp.
  170-220 Hz @ 6.0 G's peak
  220-260 Hz @ 0.0024 in. (0.0081 cm) D. A. Disp.
  260-600 Hz @ 8.0 G's peak

2. Trucks

- Smooth Paved Roads (5-300-5 Hz @ 1 oct. /min)

  1- 4 Hz @ 0.43 in. (1.09 cm) D. A. Disp. *
  4- 5 Hz @ 0.35 G's peak*
  5-150 Hz @ 0.35 G's peak
  150-300 Hz @ 0.06 G's peak

*Design Criteria Only--No Test Required.

- All Road Conditions (7-1000-7 Hz @ 1 oct./min)

1- 7 Hz @ 1.7 G's peak*
7- 15 Hz @ 1.7 G's peak
15-1000 Hz @ 0.7 G's peak

3. Trains

- Normal Railroad Operations (6-2000-6 Hz @ 1 oct./min)

2- 3 Hz @ 2.6 in. (6.60 cm) D. A. Disp.*
3- 6 Hz @ 1.2 G's peak*
6- 130 Hz @ 1.2 G's peak
130- 185 Hz @ 0.0014 in. (0.0036 cm) D. A. Disp.
185-2000 Hz @ 2.5 G's peak

4. Ships

- Normal Maneuvers (5-300-5 Hz @ 1 oct./min)

0.1- 0.3 Hz @ 0.85 G's peak*
0.3- 1.5 Hz @ 0.35 G's peak*
1.5- 4 Hz @ 0.10 G's peak*
4 - 5 Hz @ 0.12 in. (0.30 cm) D. A. Disp*
5 - 11 Hz @ 0.12 in. (0.30 cm) D. A. Disp.
11 -300 Hz @ 0.75 G's peak

B. Shock

Shock tests should be conducted by applying 5 shocks in each of three mutually perpendicular axes (15 shocks total). Any shock pulse that results in a spectrum as severe as that presented below will be acceptable.

1. Railroad

- Car Humping Conditions (5 shocks/axis)

20-160 Hz @ +6 dB/oct.
160-340 Hz @ 500 G's peak
340-400 Hz @ -6 dB/oct.

*Design Criteria Only--No Test Required.

SECTION X. HANDLING SPECIFICATIONS

Where equipment design allows, equipment shall be tested to handling specifications as described below. If normal equipment design does not allow this type testing, the procedures and required protection in handling are to be submitted to MSFC, ED23 for approval.

A. Transit Drop Test

This procedure shall be used for equipment, in its transit or combination case as prepared for field use, to determine if the equipment is capable of withstanding the shocks normally induced by loading and unloading of equipment.

B. Test Conditions

The test item shall be in its transit or combination case. For equipment 1,000 lb (453.6 kg) or less, the floor or barrier receiving the impact shall be of solid, 2 in. (5 cm) thick, plywood backed by either concrete or a rigid steel frame. For equipment over 1,000 lb (453.6 kg), the floor or barrier shall be concrete or its equivalent.

C. Performance of Test

Subject the test item to the number and heights of drop as required in Table I on page 47. Upon completion of the test, the test item shall be operated and the results compared with the data obtained in accordance with the following:

Prior to proceeding with any of the test methods, the test item shall be operated under standard ambient conditions and a record made of all data necessary to determine compliance with required performance. These data shall provide the criteria for checking satisfactory performance of the test item either during, or at the conclusion of the test, or both, as required. Certification by signature and date block is required.

The test item shall then be visually inspected and a record made of any damage deterioration resulting from the test. If a test chamber is used for the test, perform a visual inspection of the test item within the chamber at test conditions, when possible. Upon completion of the test, visually inspect the test item again after the test item has been returned to standard ambient conditions. Deterioration, corrosion, or change in tolerance limits of any internal or external parts which could in any manner prevent the test item from meeting operational service or maintenance requirements shall provide reason to consider the test item as having failed to withstand the conditions of the test.

TABLE I. TRANSIT DROP TEST

Weight of Test Item and Case lb (kg)	Largest Dimensions in. (cm)	Notes	Height of Drop in. (cm)	No. of Drops
Under 100 lb (45.4 kg) man-packed and man-portable	Under 36(91)	A	48(122)	Drop on each face, edge, and corner
	36(91) and over	A	30(76)	Total of 26 drops
100 (45.4 kg) to 200 lb (90.8 kg) inclusive	Under 36(91)	A	30(76)	
	36(91) and over	A	24(61)	Drop on each corner
Over 200 (90.8 kg) to 1,000 lb (453.6 kg) inclusive	Under 36(91)	A	24(61)	
	36(91) to 60(152)	B	36(91)	Total of 8 drops
	Over 60(152)	B	24(61)	
Over 1,000 (453.6 kg)	No limit	C	18(46)	4 edgewise drops 2 cornerwise drops

Note A. Drops shall be made from a quick-release hook; or drop tester as made by the L.A.B. Corporation, Skaneateles, New York, or equal. The test item shall be oriented so that upon impact a line from the struck corner or edge to the center of gravity of the case and contents is perpendicular to the impact surface.

Note B. With the longest dimension parallel to the floor, the transit or combination case, with the test item within, shall be supported at the corner of one end by a block 5 in. (13 cm) in height, and at the other corner or edge of the same end by a block 12 in. (30 cm) in height. The opposite end of the case shall then be raised to the specified height at the lowest unsupported corner and allowed to fall freely.

Note C. While in the normal transit position, the case and contents shall be subjected to the edgewise and cornerwise drop test as follows (if normal transit position is unknown, the case shall be oriented such that the two longest dimensions are parallel to the "floor").

1. Edgewise Drop Test. One edge of the base of the case shall be supported on a sill 5 in. (13 cm) to 6 in. (15 cm) in height. The opposite edge shall be raised to the specified height and allowed to fall freely. The test shall be applied once to each edge of the base of the case (total of four drops).

2. Cornerwise Drop Test. One corner of the base of the case shall be supported on a block approximately 5 in. (13 cm) in height. A block norminally 12 in. (30 cm) in height shall be placed under the other corner of the same end. The opposite end of the case shall be raised to the specified height at the lowest unsupported corner and allowed to fall freely. This test shall be applied once to each of two diagonally opposite corners of the base (total of two cornerwise drops). When the proportions of width and height of the case are such as to cause instability in the cornerwise drop test, edgewise drops shall be substituted. In such instances two more edgewise drops on each end shall be performed (four additional edgewise drops for a total of eight edgewise drops).

SECTION XI. INDEX OF SPECIFICATIONS

This section provides a complete index of the Zones, Subzones, and Individual Components within each zone, and also a complete index of the specific component specifications.

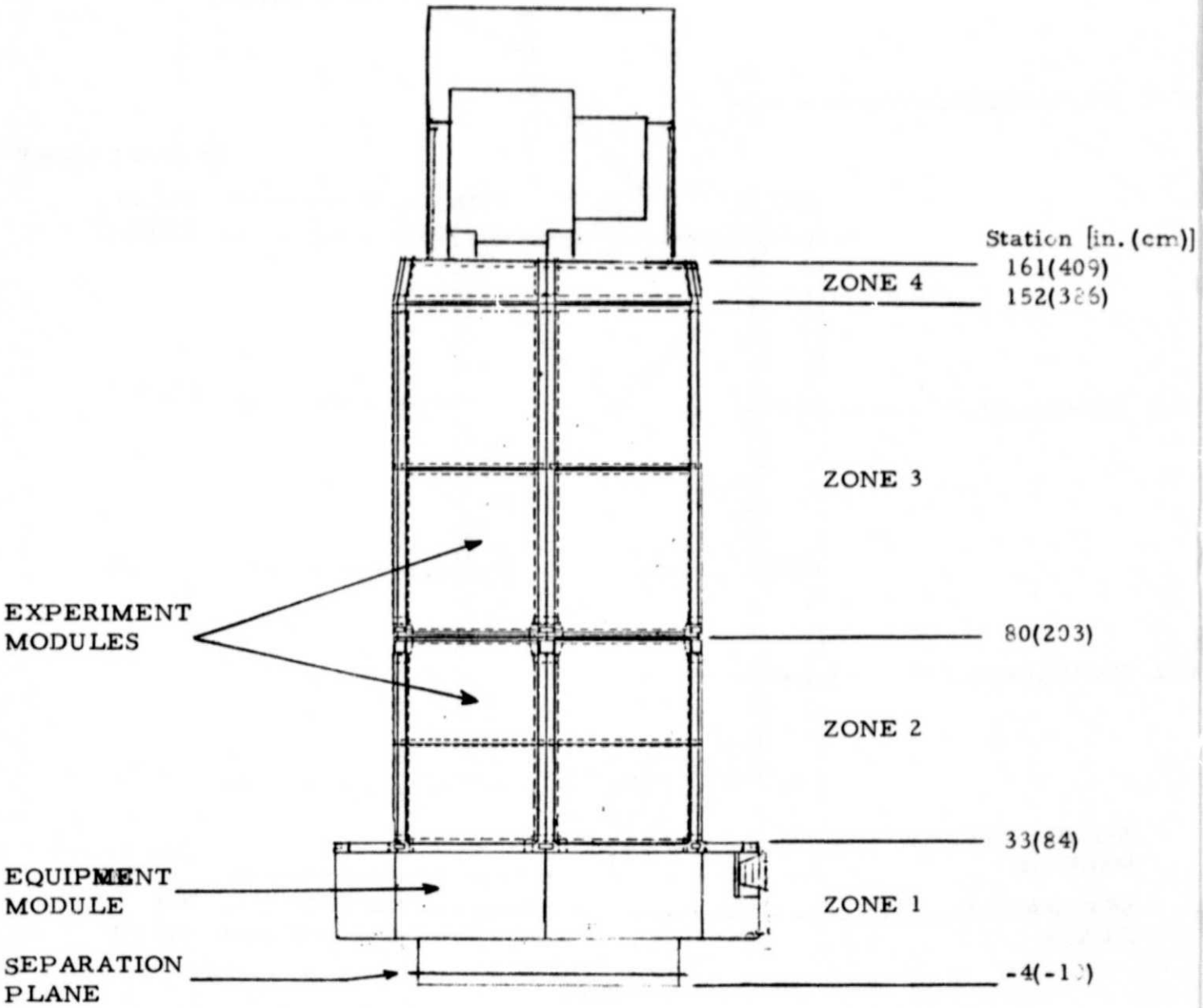

FIGURE 1 HEAO-C STRUCTURAL ZONES

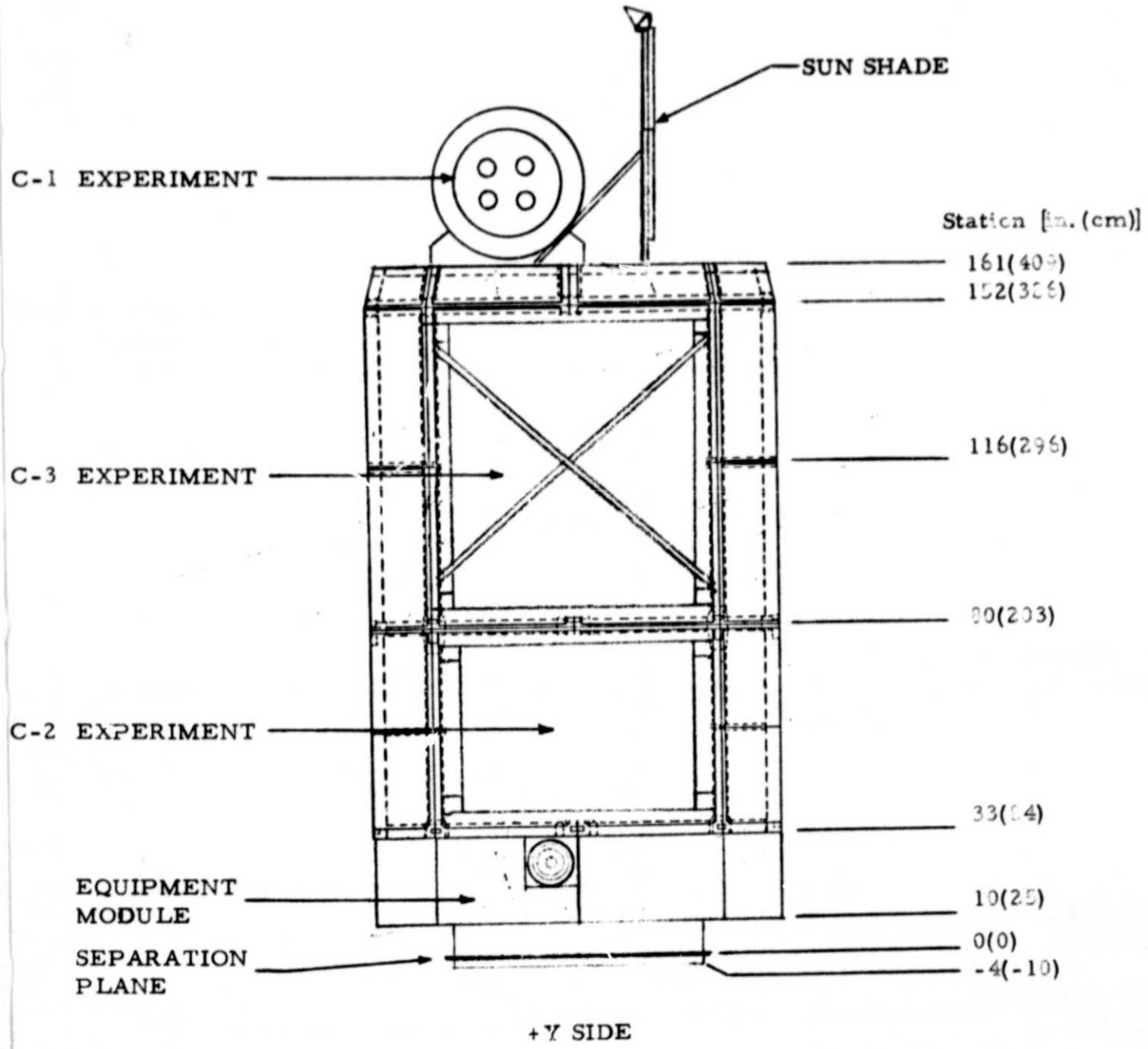

FIGURE 2 HEAO-C EXPERIMENT LOCATIONS

APPROVAL

PRELIMINARY VIBRATION, ACOUSTIC, AND SHOCK DESIGN AND TEST CRITERIA FOR COMPONENTS ON THE HEAO-C SPACECRAFT

by

Systems Dynamics Laboratory

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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